Multiplexed Sensor for Synthesis Gas Composition and Temperature

Steven G. Buckley

University of California, San Diego
Department of Mechanical and Aerospace Engineering
9500 Gilman Drive; MS 0411
La Jolla, CA 92093-0411

858-534-5681 (phone)
858-534-5354 (fax)
buckley@ucsd.edu

Grant number DE-FG26-04NT42178
Performance Period : 9/1/04 – 10/31/06

Objectives:
The overall goal of this project is to develop a highly sensitive, multiplexed TDL-based sensor for CO_2, CO, H_2O (and temperature), CH_4, H_2S, and NH_3. Additional gases may be considered based on availability of lasers. Such a sensor will be designed with so-called "plug-and-play" characteristics to accommodate additional sensors, and will provide *in situ* path-integrated measurements indicative of average concentrations at speeds suitable for direct gasifier control. The sensor will work over a range of pressures and temperatures expected in an operating gasifier. The products of this research are expected to have a direct impact on gasifier technology and the production of high-quality syngas, with substantial broader application to coal and other energy systems.

Phase I of the project was devoted to finalizing both the spectroscopic and mechanical design of the sensor. Phase II has focused on construction and development of the probe for high temperature and high pressure measurements in a laboratory setting. Finally, Phase III of the project will involve testing of the sensor in a real-world setting.

Accomplishments to date:
Phase I of this project is complete. Diagnostic wavelengths corresponding to measurement of CO, CO_2, H_2O, CH_4, NH_3, and H_2S have been selected, and lasers for each of these gases have been ordered. The H_2O, CH_4, CO, and CO_2 sensors have been completely characterized over a range of temperatures from room temperature to 1000 ºC (Fig. 1), and pressure broadening has been measured for with major collision partners for each of these species. Additional glass spectroscopic cells for NH_3 and H_2S, which present handling challenges due to their toxicity and their stickiness, have been fabricated and these molecules are being measured.

Considerable effort went into development of hardware for data processing; a National Instruments high speed data acquisition system provides the high frequency lock-in modulation necessary for the high speed measurements and provides the lock-in detection in programmable (Labview™) software, which was completed in Fall 2005. A housing and control system was also completed in September, 2005.

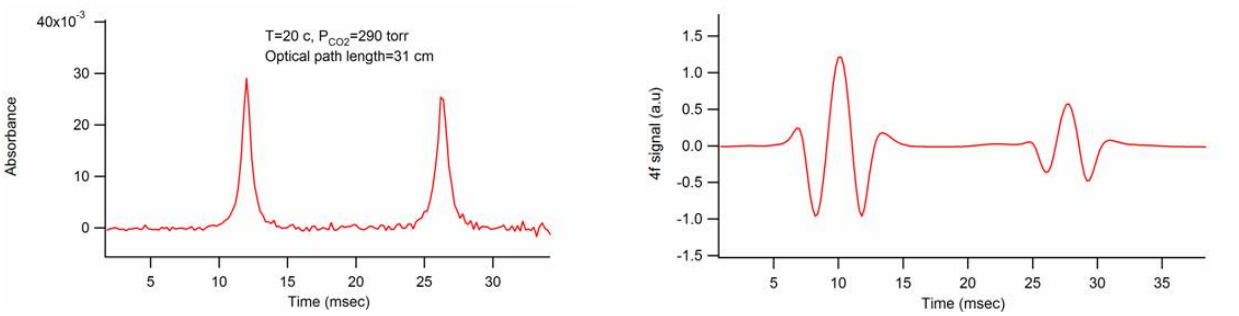

Figure 1: Direct absorption and 4th harmonic wavelength modulation spectroscopy signals corresponding to CO_2 at room temperature.

Two field trials of the system on the UCSD gas turbine stacks have validated the measurement hardware and allowed us to iron out bugs in the software and hardware.

Future work:
H_2S and NH_3 laboratory measurements must be finalized.

Initial contacts have been made to facilitate the Phase III field test, with further progress toward defining this event expected in the next six months.

Papers in preparation (partially or fully supported by this grant):
M. Gharavi and S.G. Buckley, **Diode Laser Absorption Spectroscopy Measurement of Line Strengths and Pressure Broadening Coefficients of H_2O,** submitted to *Journal of Quantitative Spectroscopy and Radiative Transfer.*

M. Gharavi and S.G. Buckley, **Wavelength Modulation Spectroscopy for Temperature and H2O Concentration Measurement using a single diode laser,** to be submitted to *Applied Optics*.

M. Gharavi, M. Leon, and S.G. Buckley, **Real-Time Measurement of H_2O, CO, and Temperature in an Operating Gas Turbine,** to be submitted to *Measurement Science and Technology*.

A. Schuger, M. Gharavi, and S.G. Buckley, **In-Flame, Real-Time Measurement of H_2O, CO, OH, and Temperature**, to be submitted to *Combustion Science and Technology.*

M. Gharavi, C. Lao, and S.G. Buckley, **Line Strengths and Pressure Broadening of Selected Transitions of CO and CO_2**, to be submitted to *Journal of Molecular Spectrosocpy*.

Students / trainees supported under this grant:
Dr. Mohammadreza Gharavi (post-doctoral researcher)
Ariel Schuger (graduate student)
Geoff Rapoport (undergraduate, then graduate student)